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The taxonomic status of the South African straptail, *Macruronus capensis* Davies, 1950 (Pisces, Gadiformes, Macruronidae)

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Abstract

The first record of the straptail fish, genus *Macruronus*, from South Africa was based on a single specimen captured off the Atlantic Cape coast and described as a new species, *M. capensis* Davies 1950. Davies did not examine specimens of the other extant nominal species in the genus, but based his conclusions solely on references to the original descriptions of *M. novaezelandiae* (Hector 1870) and *M. magellanicus* Lönnberg 1907. We show that all of the characters used by Davies (1950) to distinguish *M. capensis* from its congeners are in fact shared by the other nominal species of this genus. We also present molecular evidence from a *Macruronus* specimen recently caught off South Africa to support the conclusion that *M. capensis* is a junior synonym of *M. novaezelandiae*.

Key words: *Macruronus novaezelandiae*, molecular genetics, synonym, taxonomy

Introduction

The genus *Macruronus* comprises three valid species (Eschmeyer *et al*. 2016) of which two, *M. novaezelandiae* and *M. capensis*, inhabit the cold temperate regions of the Southern Hemisphere. The status of the third species, *M. maderensis*, from off Madeira Island, Eastern Atlantic, is uncertain (Inada 1990; Howes 1991; Lloris *et al*. 2016) as it was described from eight juvenile specimens (largest 85 mm) recovered from the stomach of an *Alepisaurus ferox* (Maul 1951). In South America, Australia and New Zealand waters, *M. novaezelandiae* supports an important commercial fishery (Inada 1990; Lloris *et al*. 2003).

The first *Macruronus* recorded from South Africa was a 1035 mm female captured 50 miles northwest of Cape Town at a depth of 426 m (Davies 1950). Davies (1950) did not examine any other *Macruronus* specimens, but compared the specimen to the original descriptions of *M. novaezelandiae* (Hector 1870) and *M. magellanicus* Lönnberg 1907. He concluded that, although it was very similar to the other *Macruronus* species, there were some substantial differences and he described the specimen as a new species, *M. capensis*. Davies (1950) noted that the specimen had been severely damaged in the trawl during capture and showed "considerable decomposition". He made no mention of whether (or where) the type specimen had been lodged. We searched the databases of several fish collections in which Davies could have deposited his specimen, including the Natural History Museum, London; The Academy of Natural Sciences of Drexel University, USA; the Muséum national d'Histoire naturelle, Paris, as well as the South African Institute for Aquatic Biodiversity (then the Department of Ichthyology, Rhodes University) and the Iziko South African Museum. However, there is no record of the specimen in the collections of these Institutions, or any material that could correspond to his specimen. It seems highly likely that he did not retain the specimen.

Lloris *et al.* (2003) reviewed the genus *Macruronus* and, based on a morphological comparison, concluded that *M. magellanicus* is a junior synonym of *M. novaezelandiae*. However, they retained *M. capensis* because they were unable to examine material of this species. The molecular study of Olavarría *et al.* (2006) confirmed the synonymy of *M. magellanicus* and *M. novaezlandiae*. These authors also excluded *M. capensis* from their analysis, accepting

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its validity with the caveat that the nature of the studies by Inada (1990) and Lloris *et al*. (2003) precluded a re-evaluation of their decisions. In this study we use morphology and molecular genetics to compare *M. capensis* and *M. novaezelandiae* to establish the status of the former species.

In placing *Macruronus* in its own family we follow Howes (1991) and Roa-Varon & Orti (2009).

Material and methods

Morphology. We recorded, where possible, all the morphometric and meristic characters that have been published for *M. capensis* (Davies 1950; Cohen 1986; Inada 1990; Lloris *et al.* 2003) from each specimen we examined. We put particular emphasis on the morphology of the head as Livingston & Schofield (1996) found these characters useful in discriminating between stocks of *M. novaezelandiae* off New Zealand.

Body depth is the deepest part of the body below the first dorsal fin; eye diameter is the fleshy horizontal diameter; head length is the distance between tip of upper jaw and posterior edge of gill membrane; inter-orbital width is the narrowest bony width; nape width is the widest place between posterior edge of eye and upper pectoral-fin base; snout length (= preorbital length) is measured from tip of upper jaw to anterior edge of eye; postorbital length is measured between posterior edges of eye and gill membrane; and upper jaw length is the distance between tip of jaw and posterior-most point of maxilla. The count of first dorsal-fin rays excludes the first small spine occasionally present at the front end of this fin; vertebrae were counted only in specimens in which the hypural plate was present. Proportional measurements are given as percent of head length instead of the usual total or standard length because the tails are frequently damaged. Unless stated otherwise specimens length is the total length regardless of the condition of the caudal region.

Genetics. Only one tissue sample of a recently-collected specimen identified as *M. capensis*, suitable for molecular analysis, was available for this study. This specimen was trawled by the Irvin & Johnson's FV *Foxglove* off Mossel Bay (36°44'S; 021°00'E), South Africa, at 298 m on 31 October 2010. DNA was extracted from this tissue using the salting out protocol of Sunnucks & Hales (1996). The DNA barcoding (sensu Hebert *et al.* 2003) fragment of the cytochrome *c* oxidase subunit I (COI) gene was amplified by Polymerase Chain Reaction (PCR), using the primer combination VF2_t1 (Ivanova *et al.* 2007) and FishR1 (Ward *et al.* 2005). The PCR was set up in a 25 µL volume, following the protocol, concentrations and thermocycling regime of Ward *et al.* (2005). A fragment of the cytochrome *b* gene was also amplified, using the primers tGludg (Gludg-L) and CB3-H (Palumbi *et al.* 2007), and the PCR conditions of Olavarría *et al.* (2006). Successful amplification was determined as in Uiblein & Gouws (2014). Amplicons were purified using an Exonuclease I – Shrimp Alkaline Phosphate (Exo/SAP, ThermoFisher Scientific) protocol (Werle *et al.* 1994), sequenced using standard fluorescent BigDye v3.1 (Applied Biosystems, Austin, Texas) terminator chemistry in both the forward (using a M13-tailed primer for the COI sequencing) and reverse directions, and analysed on an ABI-Hitachi 3500 Genetic Analyser (Applied Biosystems) at the South African Institute for Aquatic Biodiversity. Resultant sequences were checked for quality, ambiguity and potential incorrect base calls in ChromasLITE (Technelysium, Pty Ltd). The COI fragment was subjected to an identification query within BOLD (Barcode of Life Data Systems; Ratnasingham & Hebert 2007). The cytochrome *b* sequence was aligned [using ClustalX2 (Larkin *et al*. 2007)] with and compared to the three unique haplotypes (downloaded from GenBank) present among 17 individuals of *Macruronus magellanicus* (the junior synonym of *M. novaezelandiae*) collected from southern Chile and published by Olavarría *et al.* (2006). Of these three haplotypes, two were found in single individuals, but the most common haplotype (Mno-A) was also the most common haplotype found in *M. novaezelandiae* from three fishing grounds off New Zealand and a locality west of Tasmania in an earlier study (Baker *et al.* 1995), occurring in 23 of 27 sampled individuals.

Material examined. Institutional abbreviations follow Fricke & Eschmeyer (2017).

Macruronus capensis: All from **South Africa.** SAIAB 12950, 940 mm, Mossel Bay, 34° 12' S, 022° 08' E, 28 August 1953; SAIAB 13117, 2: 990–1100 mm, probably off Port Elizabeth; SAIAB 17457, 1071 mm, off Danger Point, Western Cape, 35° 05' S, 019° E, 02 October 1982; iSAM MB-F023774, 1006 mm, W of Cape Town, 34° 21' S, 018° 29' E, 16 October 1963; iSAM MB-F024494, 1037 mm, E of Cape Point, 34° 20' S, 018° 36' E, 360 m, 05 March 1965; iSAM MB-F029384, 1045 mm, 90 miles South of Cape Agulhas, 34° 50' S, 019° 59' E, 250 m, December 1981; iSAM MB-F031029,1131 mm, off Saldanha, 33° 12' S, 017° 12' E, 400 m, 12 August 1987.

Macruronus novaezelandiae: **Australia.** CSIRO T777, 603 mm, South Australia, Great Australian Bight, 33°

20' S, 128° 25' E, 266 m, 19 March 1980; CSIRO CA2692, 626 mm, New South Wales, E of Gabo Island, 37° 38' S, 150° 14' E, 440–580 m, 19 January 1982; CSIRO C4758, 674 mm, Victoria, SW of Portland, 38° 45' S, 141° 33' E, 21 June 1976; CSIRO H3025.07, 609 mm, Western Australia, NW of Bunbury, 33° 06' S, 114° 30' E, 596 m, 25 December 1989; CSIRO H3025.08, 617 mm, collected with CSIRO H3025.07; CSIRO H3988-02, 800 mm, Tasmania, off Strahan, 42° S, 145° E, 400 m, August 1995; CSIRO H3163-01, 886 mm, Tasmania, W of Cape Sorell, 42° 10' S, 144° 43' E, 452–523 m, 10 August 1992.

New Zealand. NMNZ P.001451, 994 mm, South Island, off Cape Campbell, 41º 45' S, 174º 30' E, 91–110 m, 22 April 1954; NMNZ P.002514, 809 mm, North Island, South of Cape Palliser, 41º 47' S, 175º 02' E, 735 m, 19 April 1957; NMNZ P.038238, 1090 mm, South Island, Tasman Basin, West of northern Puysegur Trench, 44º 40' S, 166º 09' E, 0–180 m, 26 May 2001; NMNZ P.038915, 825 mm, New Zealand EEZ, south Reinga Ridge, 34º 10' S, 171º 27' E, 544–584 m, 11 May 2003; NMNZ P.054711, 725 mm and NMNZ P.054712, 821 mm, South Island, Hokitika Canyon head, 42º 33' S, 170º 35' E, 432–435 m, 03 August 2012.

Comparisons. The morphometric and meristic characters of *Macruronus capensis* and *M. novaezelandiae* are compared in Tables 1–5 and Figure 1. The data for the proportional measurements show a clear difference between the two species in the size of the head (Fig. 1a, Table 1). The ranges of the snout and postorbital length, as well as the upper jaw length and nape width completely overlap, as do most of the counts. While the ranges of the eye diameter, interorbital width and body depth overlapped only partially, their means and medians differed by less than 2% (Table 1). The wide range of second dorsal- and anal-fin rays counts (Table 3), despite the small sample size, indicates high variability for these characters in both species. The remaining meristic characters had overlapping counts (Tables 2, 4, 5) in the majority of the specimens and are therefore not useful taxonomically.

TABLE 1. Summary of morphometric and meristic data for two nominal species of *Macruronus*.

Measurements	*M. capensis* (n = 8)			*M. novaezelandiae* (n = 13)		
	Range	Mean ± std	Median	Range	Mean ± std	Median
Total length (mm)	1006–1145			603–1090		
Head length (mm)	170–197			98.7–182.3		
Head length (% preanal distance)	35.6–38.4 (n = 4)	36.8 ± 1.0	36.6	38.8–45.7 (n = 6)	42.3 ± 2.4	42.1
% Head length						
Body depth	66.8–77.8 (n = 8)	73.9 ± 3.6	75.35	68.4–86.6 (n = 13)	75.95 ± 7.5	74.0
Snout length	27.7–32.9 (n = 8)	31.8 ± 1.3	32.2	29.4–32.4 (n = 7)	31.1 ± 1.1	31.0
Eye diameter	21.0–26.4 (n = 8)	24.8 ± 1.4	25.4	24.4–28.5 (n = 7)	25.8 ± 1.2	25.4
Postorbital length	41.6–46.7 (n = 8)	44.9 ± 3.7	45.2	43.4–45.9 (n = 7)	45.0 ± 0.9	45.6
Upper jaw length	50.9–53.8 (n = 8)	52.15 ± 4.3	53.4	49.7–60.7 (n = 7)	53.2 ± 3.3	52.7
Interorbital width	18.1–21.5 (n = 7)	20.4 ± 1.05	20.8	19.5–25.0 (n = 13)	21.8 ± 1.55	21.4
Nape width	32.8–40.8 (n = 8)	37.0 ± 3.0	37.15	36.1–40.6 (n = 13)	38.5 ± 1.5	38.7
Counts	n = 8			n = 6		
Left pelvic-fin rays	8			8		
Right pelvic-fin rays	8			8		
Anal-fin rays	84–99		91.5	84–104		95
Vertebrae	77–79 (n = 6)			78–81*		
Canines	Present			Present		
Oral cavity colour	Dusky to dark			Dusky		

* Data from Bruce (1998), and two examined specimens (CSIRO H3025.07 and H3025.08)

A 649 nucleotide fragment of COI and an 837 nucleotide cytochrome *b* fragment were produced from the single *M. capensis* sample. These are lodged in GenBank under accession numbers MF540919 and MF488977, respectively. The identification query using the COI sequence on BOLD returned matches with greater than 99.3% identity/similarity (roughly three base differences over the length of sequence considered) with published data of

both *M. magellanicus* and *M. novaezelandiae* (99.38% similarity with both species). A single comparison with published data from a *M. magellanicus* specimen yielded 99.84% similarity. Once the cytochrome *b* sequence was aligned with the three published haplotypes (Olavarría *et al.* 2006), 389 nucleotides were available for comparison. The present *M. capensis* haplotype was identical to haplotype Mnov-A (DQ364239), the most abundant haplotype in the samples of both *M. novaezelandiae* and *M. magellanicus* examined in earlier studies (Baker *et al.* 1995; Olavarría *et al.* 2006). The *M. capensis* haplotype differed from the other two *M. magellanicus* haplotypes (Mmag-1, DQ364240 and Mmag-2, DQ364241; Olavarría *et al.* 2006) by a single base pair in each case.

TABLE 2. Frequency distribution of first dorsal fin rays in two nominal species of *Macruronus.*

	First dorsal fin rays				
	10	11	12	13	14
M. novaezelandiae	1		4	1	
M. capensis			4	3	1

TABLE 3. Frequency distribution of second dorsal and anal fin rays in two nominal species of *Macruronus*.

	Number of fin rays													
	84	89	91	92	94	95	96	98	99	100	102	103	104	105
Second dorsal fin														
M. novaezelandiae							1			1	2	1	1	
M. capensis				1		1			2					1
Anal fin														
M. novaezelandiae	1		1	1				1					2	
M. capensis	1	1			1				1					

TABLE 4. Frequency distribution of pectoral fin rays in two nominal species of *Macruronus.*

	Left pectoral fin				Right pectoral fin			
	15	16	17	18	15	16	17	18
M. novaezelandiae	2	2	1	1	1	3		2
M. capensis	2	1	5		2	1	5	

TABLE 5. Frequency distribution of gill rakers in two nominal species of *Macruronus.*

	Upper limb			Lower limb				Total			
	5	6	7	21	22	23	24	28	29	30	31
M. novaezelandiae	1	2	3	1	1		4	1	2	2	1
M. capensis		2	6		5	2	1	2	3	2	1

Remarks. The genetic analyses presented here, although based on a single specimen of *M. capensis*, provide evidence for its synonymy with *M. novaezealandiae*, along with *M. magellanicus*. Olavarría *et al.*'s (2006) molecular study, using cytochrome *b* data from the same fragment, argued for the status of *M. magellanicus* as a junior synonym of *M. novaezelandiae*, based on the lack of differentiation among the two populations; a shared haplotype was the most abundant in both species, and low levels of population differentiation were only due to rare haplotypes within each. In the present case, the *M. capensis* cytochrome *b* haplotype is identical to this shared, common haplotype in *M. magellanicus* (Olavarría *et al.* 2006) and *M. novaezelandiae* (Baker *et al.* 1995; Olavarría *et al.* 2006). While the analysis of a single specimen precludes a more detailed consideration of population differentiation, the comparison of this sequence to other sequences from *M. magellanicus* reveals this divergence to be no more extensive than divergences among the *M. magellanicus* sequences themselves. The BOLD identification, based on the COI sequence, supports this conclusion, with the *M. capensis* haplotype being highly

similar (with one to three nucleotide substitutions) to published data from specimens identified as *M. novazelandiae* and *M. magellanicus*.

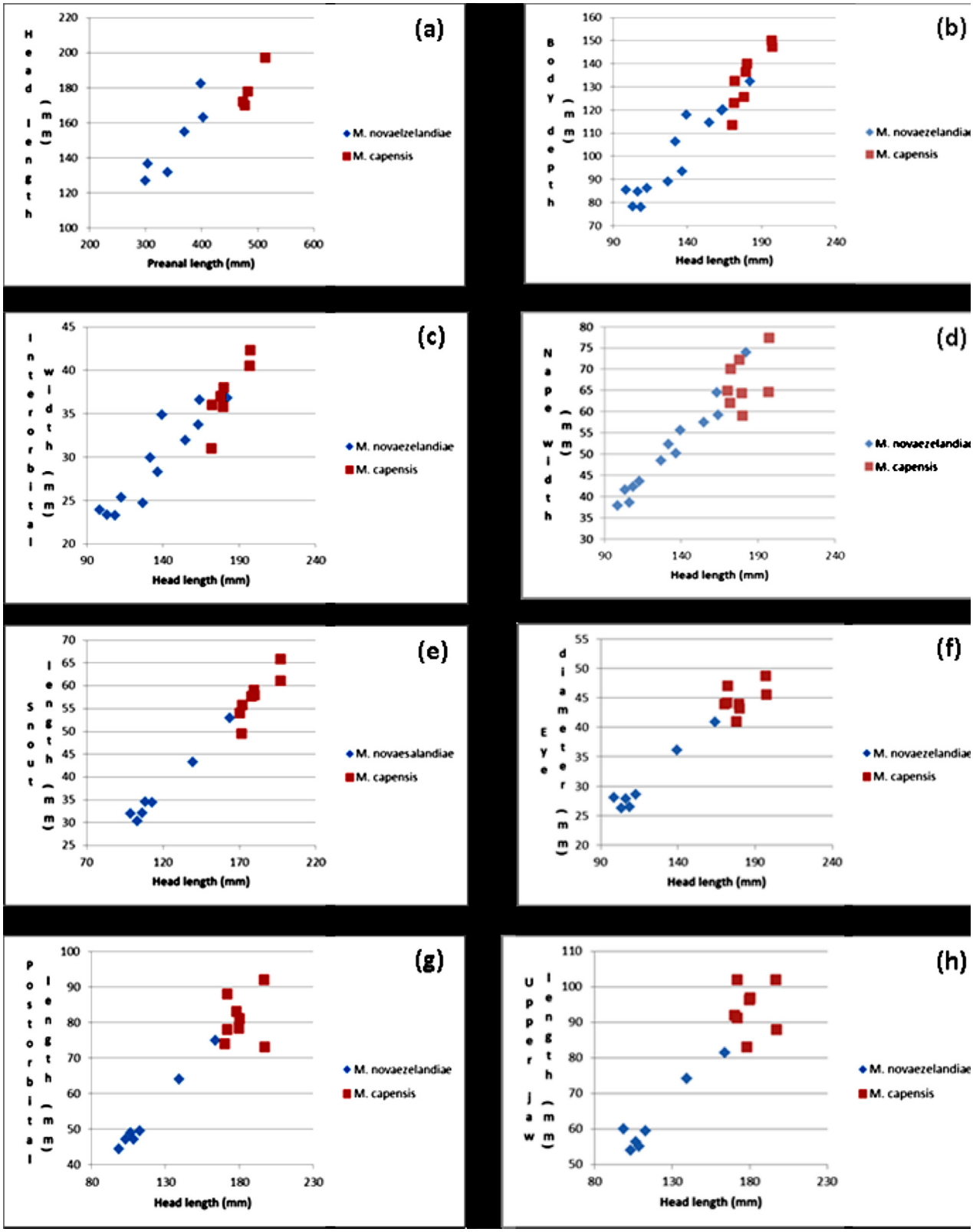

FIGURE 1. Relationships between morphometric characters and measures of body length in two nominal species of *Macruronus*.

Studies of *Macruronus novaezelandiae* found different growth rates (Livingston *et al*. 1992; Horn & Sulllivan 1996), and a significant difference in head length (Livingston & Schofield 1996) between stocks inhabiting water masses with different oceanographic characteristics in New Zealand. Therefore, we do not consider the difference in the head length between *M. capensis* and *M. novaezelandiae* a reliable indication of species level difference. Similarly, the small modal differences between the two species in eye diameter, interorbital width and body depth could also be a consequence of habitat differences. Furthermore, body depth in this group of species is measured across the soft abdominal area (Lloris *et al*. 2003) which can be affected by stomach fullness and the state of gonad development. These fishes are also soft bodied, and frequently subjected to damage when trawled. This adds another level of variability and uncertainty to measurements.

Davies (1950) regarded dentition as the most striking difference between the taxa. Lönnberg (1907) made no mention of upper jaw teeth in *M. magellanicus* and although Hector (1870) stated that in *M. novaezelandiae* the upper jaw teeth are bi-serial, these teeth are not visible in his illustration of this species. Consequently, Davies (1950) apparently assumed that upper jaw teeth were absent in *M. magellanicus* and were in a weak bi-serial row in *M. novaezelandiae*, as opposed to the single series of strong curved teeth he found in both jaws of his *M. capensis*. Both *M. novaezelandiae* and *M. magellanicus* have since been shown to have strong curved teeth in a single series in the lower jaw and two series in the upper jaw; the inner series is small and often embedded and visible only when the tissue covering the inner surface of the jaw is removed (Howes 1991). Most of the specimens of *M. novaezelandiae* and *M. capensis* we examined had the typical dentition pattern described by Howes (1991). One specimen (iSAM MB-F023774) of the latter species had a single series of teeth in the upper jaw and in two fish (SAIAB 17457, iSAM MB-F031029) the second series was embedded in the soft tissue.

Davies (1950) considered the small spine anterior to the first dorsal fin a unique character of *M. capensis* because neither Hector (1870) nor Lönnberg (1907) mentioned this. Howes (1991) showed that this small spine is a characteristic of the genus.

Davies (1950) also noticed that "there are wide discrepancies between fin counts of the second dorsal and anal fins". It is difficult to understand the basis for this statement because he earlier stated that the specimen was severely damaged in the net and was partly decomposed by the time it was brought ashore and frozen. Consequently his fin ray counts for the second dorsal and anal fins were likely approximate values.

Davies (1950) regarded the capture depth of the South African specimen (280 fathoms/426 m) as evidence that *M. capensis* was a species "of deeper habitat" than the other congeners because the other two *Macruronus* species were captured shallower than 28 fathoms (43 m). However it is now known that *Macruronus* occurs at depths of at least 800 m off South America (Lloris *et al*. 2016) and over 1000 m in New Zealand (Stewart 2015; RWL, pers obs).

The *Macruronus* populations off South America and off Australasia support substantial fisheries. By contrast, in the 67 years since the first *Macruronus* was recorded off South Africa only 10 individuals have been reported, all large adults (1006–1145mm). Thus there is no evidence of a resident population off South Africa. Instead, the records of *Macruronus* from off South Africa are suggestive of the erratic occurrence of vagrants from established populations elsewhere.

Given the lack of morphological and genetic differences between *M. capensis* and *M. novaezelandiae*, and the absence of evidence of a resident population of *Macruronus* off southern Africa, we conclude that *M. capensis* is a junior synonym of *M. novaezelandiae*.

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Andrew Stewart of the Museum of New Zealand Te Papa Tongareva kindly provided data from New Zealand hoki specimens. We thank Alistair Graham for his assistance to RWL when he visited the CSIRO collection in Hobart, and C. Borland of the Twin Oaks Veterinary Clinic for taking x-rays of the four iSAM specimens. We also thank N. Mazungula, B. Konqobe, M. Dwani and V. Hanisi of SAIAB for handling specimens. We are grateful for the support provided by the National Research Foundation (NRF) of South Africa. We acknowledge that opinions, findings and conclusions or recommendations expressed in this publication, generated by the NRF supported research, are those of the authors, and that the NRF accepts no liability whatsoever in this regard.

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